

Mass-Mass Relationships in Reactions

Lab 17

Text reference: Chapter 10, pp. 239–243

Pre-Lab Discussion

As you have learned, given a balanced chemical equation and the mass of one of the substances in the reaction, the mass of any other substance in the reaction can be calculated. Calculations in which a known mass is used to find an unknown mass in a chemical reaction are called mass-mass calculations.

In this experiment, a double replacement reaction will occur when an aqueous solution of a hydrate of zinc acetate is mixed with an aqueous solution of a hydrate of sodium phosphate tribasic. There are two products of this reaction. One is the insoluble solid (zinc phosphate), which will precipitate out of solution. The other is a soluble salt (sodium acetate), which will remain in solution. The insoluble solid will be separated from the liquid and dried, and its mass determined. The value of the experimentally measured mass of the compound will be compared with the theoretical mass of the compound predicted by a mass-mass calculation.

You may recall that the hydrates of ionic substances have water molecules bound into their crystalline structure. However, they look and feel perfectly dry. When doing mass calculations that involve hydrates, you must be careful to include the mass of the water molecules. For example, the mass of one mole of $\text{CaBr}_2 \cdot 6\text{H}_2\text{O}$ is 308 g/mole:

$$\left. \begin{array}{l} \text{Ca: } 1 \times 40 \text{ g/mole} = 40 \text{ g} \\ 2\text{Br: } 2 \times 80 \text{ g/mole} = 160 \text{ g} \\ 6\text{H}_2\text{O: } 6 \times 18 \text{ g/mole} = 108 \text{ g} \end{array} \right\} 308 \text{ g/mole } \text{CaBr}_2 \cdot 6\text{H}_2\text{O}$$

This experiment further emphasizes the importance of mass-mass calculations in the chemistry laboratory.

Purpose

To compare the theoretical mass of one of the products of a double replacement reaction with the experimentally determined mass of the same product.

Equipment

| | |
|----------------------------|-------------------|
| balance | ring stand |
| graduated cylinder, 100-mL | iron ring |
| beakers, 250-mL (2) | funnel |
| beaker, 100-mL | safety goggles |
| stirring rod | lab apron or coat |

Materials

zinc acetate hydrate $[\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}]$
sodium phosphate tribasic hydrate $(\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O})$
filter paper

Safety



Handle glassware with care to avoid breakage. Always wear safety goggles and a lab apron or coat when working in the lab.

Procedure

1. Using the balance, measure out exactly 1.10 g of zinc acetate hydrate $[\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}]$. Record this mass as (a) in your list of data.
2. Place the $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ in a clean 250-mL beaker and add 50 mL of water. Stir thoroughly to make sure *all crystals are dissolved*. Rinse off the stirring rod.
3. Measure out approximately 1.35 g of sodium phosphate tribasic hydrate ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$). Place it in a clean 100-mL beaker and add 50 mL of water. Stir until all crystals are dissolved.
4. Pour the $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ solution into the 250-mL beaker containing the solution of $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$. Stir. Record your observations as (d) in your list of data.
5. Find the mass of a piece of filter paper. Record this as mass (b). Fold the filter paper and place it in the funnel.
6. Pour the mixture from the 250-mL beaker into the funnel as shown in Figure 17-1. *Pour slowly*. Do not allow the liquid to rise above the edge of the filter paper in the funnel.

Write your names in
pencil on the filter paper
before you get a mass of it.

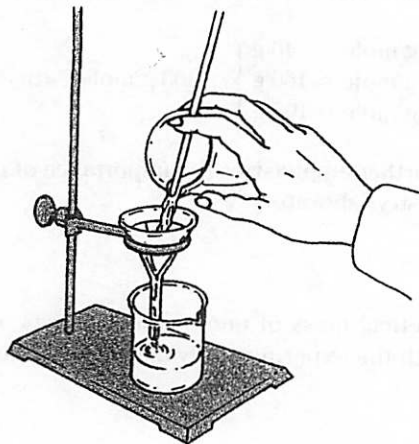


Figure 17-1

7. Rinse the beaker with about 20 mL of water. Pour the rinse water through the filter. Repeat the rinsings and filterings until all the precipitate is out of the beaker.
8. Wash the precipitate by pouring about 10 mL of clean water through the filter.
9. Remove the filter paper and precipitate from the funnel and place overnight in an oven to dry at about 45°C .
10. Find the mass of the *dry* precipitate + filter paper [mass (c) in your list of data].

Mass Relationships in a Chemical Reaction Lab

Observations

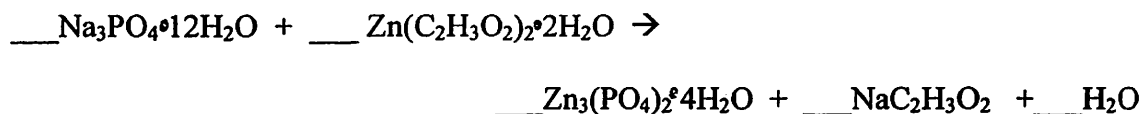
What happened when the two solutions you made were combined?

Data

- a. exact mass of $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ used _____ g
- b. mass of both filter papers _____ g
- c. mass of filter paper and precipitate _____ g
(this mass is taken next day)

Calculations

1. Balance the equation for the reaction that you did in today's lab.



The precipitate in this lab is the $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$.

2. Now do the stoichiometry and find the theoretical mass of precipitate that should have been produced.

- a. Calculate the molar mass of $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ _____ g/mol
- b. Convert the mass of $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ you used (1a) to moles using its molar mass (2a).
- c. Convert the moles of $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ (2b) to moles of $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ using a molar ratio from the reaction (1).
- d. Calculate the molar mass of $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ _____ g/mol
- e. Convert moles of $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ (2c) to grams of $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ produced using its molar mass (2d).

3. Find the experimental mass of $\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$ produced. (Data sections c – b)

4. Find your percent yield from the reaction

$$\% \text{ yield} = \frac{\text{actual yield (3)} - \text{theoretical yield (2e)}}{\text{theoretical yield (2e)}}$$

Conclusions and Questions

What is another name for a double replacement reaction?

What must one of the products be in a double replacement reaction?

What does your percent yield (4) indicate in this reaction?

What does it mean if percent yield is above 100%?

What does it mean if percent yield is below 100%?

Define the following terms:

Precipitate-

Filtrate-

Actual Yield-

Theoretical Yield-